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Art Unit	1763
Examiner Name	Rudy Zervigon
Attorney Docket Number	1084D01T9320
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  - ☐ Fee Attached
- ☐ Amendment/Reply
  - ☐ After Final
  - ☐ Affidavits/declaration(s)
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- ☐ Information Disclosure Statement
- ☐ Certified Copy of Priority Document(s)
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SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

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On April 5, 2004

TOWNSEND and TOWNSEND and CREW LLP

By:

PATENT
Attorney Docket No.: 1084D01T9320
TTC No.: 16301-009320

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re application of:	Confirmation No.: 9377
DAVID CHEUNG et al.	Examiner: Rudy Zervigon
Application No.: 09/418,818	Art Unit: 1763
Filed: October 15, 1999	APPELLANT'S BRIEF UNDER 37 CFR § 1.192
For: METHOD AND APPARATUS FOR DEPOSITING ANTIREFLECTIVE COATING	
Customer No.: 20350	

Mail Stop Appeal Brief
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Applicants, in the above-captioned patent application, appeal the final rejection of claims 1-6, 9, 10 and 44-62. The claims on appeal have been finally rejected pursuant to MPEP § 706.07(b). Accordingly, this appeal is believed to be proper. This appeal brief is filed in triplicate.

I. REAL PARTY IN INTEREST:

The real party in interest for the above-identified application is APPLIED MATERIALS, INC., a Delaware corporation having its principal place of business at P.O. Box

450A, Santa Clara, California 95052. The assignment is recorded in the U.S. Patent and Trademark Office on June 28, 1996 at Reel 8078/Frame 0829.

II. RELATED APPEALS AND INTERFERENCES:

There are no appeals or interferences related to the present appeal.

III. STATUS OF CLAIMS:

Claims 1-6, 9, 10 and 44-62 are pending.

Claims 1-6, 9, 10, 44-50, 53-57, and 62 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. (USP 4,888,199) in view of Batey et al. and Lee (USP 5,286,581).

Claim 51 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. and Batey et al. and Lee, in view of Felts et al. (USP 5,364,665).

Claims 52, 58, and 59 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al., Batey et al., and Lee, in view of Collins et al. (USP 5,300,460).

Claims 60 and 61 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Batey et al. in view of Lee.

IV. STATUS OF AMENDMENTS:

Applicants filed a Response to Office Action under 37 C.F.R. § 1.116 on December 8, 2003.

In an Advisory Action dated January 15, 2004, the Examiner maintained the rejection of all pending claims.

In accordance with 37 C.F.R. § 1.192(c)(9), a copy of the claims involved in the appeal are contained in the Appendix attached hereto.

V. SUMMARY OF THE INVENTION:

Embodiments of the present invention provide a method and an apparatus for depositing an antireflective layer. Helium gas is used to lower the deposition rate of plasma-enhanced silane oxide, silane oxynitride, and silane nitride processes. Helium is also used to stabilize the process, so that different films an be deposited. The invention provides conditions under which process parameters can be controlled to produce antireflective layers with varying

optimum refractive index, absorptive index, and thickness for obtaining the desired optical behavior.

In specific embodiments, a substrate processing system comprises a vacuum chamber, a substrate supporter located within the vacuum chamber for holding a substrate, a gas manifold for introducing process gases into the chamber, and a gas distribution system coupled to the gas manifold for distributing the process gases to the gas manifold from gas sources. A power supply is coupled to the gas manifold. The system further comprises a vacuum system for controlling pressure within the vacuum chamber, and a controller, including a computer, for controlling the gas distribution system, the power supply and the vacuum system. A memory is coupled to the controller and comprises a computer readable medium having a computer readable program code embodied therein for directing operation of the substrate processing system. The computer readable program code further includes code for controlling the gas distribution system to operate for a specified time period and for causing the first plasma enhanced CVD layer to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer.

In some embodiments, the system comprises means for forming a layer of photoresist on the antireflective layer, and means for forming a photoresist pattern by exposing the photoresist layer to the exposure light and developing the exposed photoresist layer. The antireflective layer has a thickness and refractive indices such that a first reflection from an interface between the photoresist and the antireflective layer of an exposure light will be an odd number which is at least 3 multiplied by 180° out of phase with a second reflection from an interface between the antireflective layer and the substrate layer of the exposure light.

In some embodiments, the system comprises means for forming an SiON antireflective layer over a first layer on the substrate by flowing selected deposition gases into the substrate processing chamber at deposition gas flow rates and adding a flow of an inert gas to the selected deposition gases to deposit the SiON antireflective layer at a desired deposition rate which is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas, means for forming a layer of photoresist over the antireflective layer, and means for forming a photoresist pattern by exposing the

photoresist layer to an exposure light having a wavelength of 365 nm or less and developing the exposed photoresist layer. The antireflective layer has a refractive index in the range of 1.7-2.9, an absorptive index in the range of 0-1.3, and a thickness in the range of 200-3000 angstroms. A phase shift of an odd multiple of at least 3 multiplied by 180° exists between a first reflection of the exposure light from an interface between the photoresist layer and the antireflective layer and a second reflection of the exposure light from an interface between the antireflective layer and the first layer. The first reflection has almost the same intensity as the second reflection to thereby substantially cancel the first and second reflections.

VI. ISSUES:

The following issues are presented:

Whether claims 1-6, 9, 10, 44-50, 53-57, and 62 are properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. (USP 4,888,199) in view of Batey et al. and Lee (USP 5,286,581).

Whether claim 51 is properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. and Batey et al. and Lee, in view of Felts et al. (USP 5,364,665).

Whether claims 52, 58, and 59 are properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al., Batey et al., and Lee, in view of Collins et al. (USP 5,300,460).

Whether claims 60 and 61 are properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Batey et al. in view of Lee.

VII. GROUPING OF THE CLAIMS:

In the present case, the rejected claims do not all stand or fall together. Applicants submit that each claim presents distinct issues concerning patentability. In the interest of administrative economy and efficiency, however, Applicants agree to narrow the issues for the purposes of this appeal only by grouping the claims as follows:

Group 1: Claims 1-6, 9, and 10, which relate generally to a substrate processing system having a controller for controlling the gas distribution system, the power supply and the vacuum system, and a memory coupled to the controller comprising a computer readable medium having a computer readable program code

embodied therein for directing operation of the substrate processing system, the computer readable program code including computer readable program code for causing the gas distribution system to introduce a first process gas comprising a mixture of SiH_4 and N_20 into the chamber to deposit a first plasma enhanced CVD layer over the wafer, computer readable program code for causing the gas distribution system to introduce a second process gas comprising He into the chamber to control the deposition rate of the first layer, and computer readable program code for controlling the gas distribution system to operate for a specified time period and for causing the first plasma enhanced CVD layer to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer;

Group 2: Claims 44-50, which relate generally to a substrate process system comprising a controller configured to control the power supply and the gas delivery system, and a memory coupled to the controller comprising a computer readable medium having a computer readable program embodied therein for directing operation of the substrate processing system, the computer readable program including a first set of computer instructions for controlling the gas delivery system to introduce selected deposition gases into the process chamber at deposited gas flow rates, a second set of computer instructions for controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a plasma enhanced reaction of the selected deposition gases, the desired low deposition rate being lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas, a third set of computer instructions for controlling the power supply to supply power to the process chamber to produce a plasma enhanced reaction of the deposition gases in the process chamber to deposit a film at the low deposition rate, and a fourth set of computer instructions for controlling the gas delivery system to operate for a specified time period and for causing the film to

be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the film;

Group 3: Claim 51, which is directed generally to the same subject matter as claim 44, but which includes the additional limitation that the substrate support is spaced from the gas distribution system at a distance in the range of 200-600 mils;

Group 4: Claim 52, which is directed generally to the same subject matter as claim 44, but which includes the additional limitation that the selected deposition gases further comprise NH_3 flowed into the chamber at a rate of less than 300 sccm, and N_2 flowed into the chamber at a rate of less than 4000 sccm;

Group 5: Claim 53, which relates generally to a substrate processing system comprising a controller configured to control the power supply and the gas delivery system, and a memory coupled to the controller comprising a computer readable medium having a computer readable program embodied therein for directing operation of the substrate processing system, the computer readable program including a first set of computer instructions for controlling the gas delivery system to flow He into the process chamber at a selected flow rate to provide a chamber pressure in the range of 1-6 Torr, a second set of computer instructions for controlling the RF power supply to supply power of 50-500 Watts to the process chamber, a third set of computer instructions for controlling the heater to heat the substrate to a temperature in the range of 200-400°C, a fourth set of computer instructions for controlling the gas delivery system to flow SiH_4 at a flow rate of 5-300 sccm into the process chamber, a fifth set of computer instructions to flow N_2O at a flow rate of 5-300 sccm into the process chamber, and a sixth set of computer instructions for controlling the gas delivery system to operate for a specified time period and for causing the antireflective layer to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer, wherein a ratio of the selected flow rate of He to the combined flow rate of SiH_4 and N_2O is at least 6.25:1 to deposit an antireflective layer on the substrate at a

deposition rate which is lower than a deposition rate using the same flow rate of SiH_4 and the same flow rate of N_2O with a lower flow rate of He;

Group 6: Claim 54, which relates generally to a substrate processing system comprising a controller configured to control the power supply and the gas delivery system, and a memory coupled to the controller comprising a computer readable medium having a computer readable program embodied therein for directing operation of the substrate processing system, the computer readable program including a first set of computer instructions for controlling the gas delivery system to flow selected deposition gases into the process chamber at deposition gas flow rates, a second set of computer instructions for controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a reaction of the selected deposition gases, the desired low deposition rate being lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas, a third set of computer instructions for controlling the power supply to supply power to the process chamber to react the deposition gases to deposit a film at the low deposition rate, and a fourth set of computer instructions for controlling the gas delivery system to operate for a specified time period and for causing the film to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the film;

Group 7: Claims 55 and 56, which relate generally to a substrate processing system comprising means for adding a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from plasma enhanced reaction of the selected deposition gases, the desired low deposition rate being lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas; and means for depositing a thin film at the low deposition rate from a plasma enhanced reaction of the deposition gases and for causing the thin film to be formed to a thickness which is an odd multiple, greater than one, of a

wavelength of light to be used in a subsequent process operation on the thin film;

Group 8: Claim 57, which relates generally to a substrate processing system comprising means for flowing He into the processing chamber at a selected flow rate to provide a chamber pressure in the range of 1-6 Torr; means for connecting the chamber to an RF power supply to receive 50-500 Watts; means for heating the substrate to a temperature in the range of 200-400°C; means for flowing SiH4 through a gas distribution system at a flow rate of 5-300 sccm; and means for flowing N_2O through the gas distribution system at a flow rate of 5-300 sccm, wherein a ratio of the selected flow rate of He to the combined flow rate of SiH_4 and N_2O is at least 6.25:1 to deposit an antireflective layer on the substrate at a deposition rate which is lower than a deposition rate using the same flow rate of SiH_4 and the same flow rate of N_2O with a lower flow rate of He and to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the antireflective layer;

Group 9: Claims 58-59, which are directed generally to the same subject matter as claim 57, but which include the additional limitation of means for introducing NH_3 into the chamber at a rate of 0-300 sccm;

Group 10: Claim 60, which relates generally to a substrate processing system comprising means for forming an antireflective layer over a layer on the substrate by flowing selected deposition gases into the substrate processing chamber at deposition gas flow rates and adding a flow of an inert gas to the selected deposition gases to deposit the antireflective layer at a desired deposition rate which is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas; means for forming a layer of photoresist on the antireflective layer, the antireflective layer having a thickness and refractive indices such that a first reflection from an interface between the photoresist and the antireflective layer of an exposure light will be an odd number which is at least 3 multiplied by 180° out of phase with a second reflection from an interface between the antireflective layer and

the substrate layer of the exposure light; and means for forming a photoresist pattern by exposing the photoresist layer to the exposure light and developing the exposed photoresist layer;

Group 11: Claim 61, which relates generally to a substrate processing system comprising means for forming an SiON antireflective layer over a first layer on the substrate by flowing selected deposition gases into the substrate processing chamber at deposition gas flow rates and adding a flow of an inert gas to the selected deposition gases to deposit the SiON antireflective layer at a desired deposition rate which is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas, said antireflective layer having a refractive index in the range of 1.7-2.9, an absorptive index in the range of 0-1.3, and a thickness in the range of 200-3000 angstroms; means for forming a layer of photoresist over the antireflective layer; and means for forming a photoresist pattern by exposing the photoresist layer to an exposure light having a wavelength of 365 nm or less and developing the exposed photoresist layer, wherein a phase shift of an odd multiple of at least 3 multiplied by 180° exists between a first reflection of the exposure light from an interface between the photoresist layer and the antireflective layer and a second reflection of the exposure light from an interface between the antireflective layer and the first layer, the first reflection having almost the same intensity as the second reflection to thereby substantially cancel the first and second reflections; and

Group 12: Claim 62, which relates generally to a substrate processing system comprising means for flowing selected deposition gases into the substrate processing chamber at deposition gas flow rates; means for adding a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a reaction of the selected deposition gases, said desired low deposition rate being lower than a deposition rate using said selected deposition gases at said deposition gas flow rates with a lower flow rate of said inert gas; and means for depositing a thin film on the substrate at said

low deposition rate from said reaction of said deposition gases to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the thin film.

VIII. DISCUSSION OF THE REFERENCES RELIED UPON BY THE EXAMINER:

In rejecting the claims under 35 U.S.C. § 103(a), the Examiner relied upon the following references:

1. Felts et al. (United States Patent No. 4,888,199)

Felts '199 discloses a process of depositing a thin film onto a surface of a substrate with the use of a plasma. Felts '199 discloses the use of the average electron temperature of the plasma T_e to diagnose and control the plasma deposition. "The average electron temperature of the plasma affects the film deposition rate and properties of the resulting film, so it is an important piece of information to have in a real time plasma control system." Column 2, lines 47-51. Thus, Felts '199 is concerned with achieving a desired average electron temperature of the plasma (col. 2, line 58, to col. 3, line 6). The system adjusts the helium gas flow to the plasma chamber. "An increase of the inert gas supply provides more electrons, and a decrease in the gas fewer electrons." Column 10, lines 48-50.

2. Batey et al.

Batey et al. discloses forming silicon dioxide thin films at low temperatures by plasma-enhanced chemical vapor deposition. A deposition rate much lower than that used in conventional plasma-enhanced processes is found to be crucial in obtaining material with reproducible, good properties. Controlled, slow deposition is achieved by using very low flow rates of reactive gases, together with a much higher flow of inert carrier gas to ensure uniformity. The approach adopted is to use a high flow of inert "carrier" gas (helium) to ensure uniformity and enable a wide range of deposition rate to be achieved simply by varying the reactive gas flows.

3. Lee (United States Patent No. 5,286,581)

Lee discloses a method for fabricating a phase-shift mask. To achieve the optimal phase shift of 180 degrees, d = L / (2(n-1)), where d is the thickness of the phase-shift layer, L is the wavelength of illumination (e.g., 365 nm), and n is the refractive index of phase-

shift feature, which is approximately 2.05 for Si_3N_4. The thickness d of Si_3N_4 is 1.738 angstroms. Column 5, lines 10-29.

4. Felts et al. (United States Patent No. 5,365,665)

Felts '665 discloses a plasma treating apparatus useful for coating substrates with thin films having vapor barrier properties at relatively rapid deposition rates. The method for rapid plasma treatments uses an inert gas (helium or argon) with an organosilicon compound and oxygen of the gas stream to deposit a film. "When the inert gas is helium or argon, then a suitable flow rate ratio of organosilicon compound, oxygen and inert gas is about 0.1:1.0:1.0. Other flow rate ratios may be used, however, if desirable." Column 5, lines 17-20.

5. Collins et al. (United States Patent No. 5,300,460)

Collins et al. discloses an improved method of fabricating integrated circuit structures on semiconductor wafers using a plasma-assisted process, wherein the plasma is generated by a VHF/UHF power source at a frequency ranging from about 50 to about 800 MHz. Low pressure plasma-assisted etching or deposition processes, i.e., processes may be carried out within a pressure range not exceeding about 500 milliTorr; with a ratio of anode to cathode area of from about 2:1 to about 20:1, and an electrode spacing of from about 5 cm. to about 30 cm. High pressure plasma-assisted etching or deposition processes, i.e., processes may be carried out with a pressure ranging from over 500 milliTorr up to 50 Torr or higher; with an anode to cathode electrode spacing of less than about 5 cm. By carrying out plasma-assisted processes using plasma operated within a range of from about 50 to about 800 MHz, the electrode sheath voltages are maintained sufficiently low, so as to avoid damage to structures on the wafer, yet sufficiently high to preferably permit initiation of the processes without the need for supplemental power sources.

IX. ARGUMENTS:

Because all the claims do not stand or fall together, Applicants will present arguments for each claim group.

Claim Group 1

Claims 1-6, 9, and 10 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. '199 in view of Batey et al. and Lee.

Applicants respectfully submit that independent claim 1 is patentable over the cited references because, for instance, they do not teach or suggest a computer readable program code for controlling the gas delivery system to operate for a specified time period and for causing a layer to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer.

The Examiner cites Lee for allegedly disclosing that a first reflection from an interface between the photoresist layer and the antireflective layer of an exposure light is an odd number, but it is not an odd multiple, greater than one, of the wavelength of light to be used in a subsequent process operation on the layer. Lee merely discloses a 180 degrees shift. Nothing in Lee teaches or suggests a thickness that is an odd multiple, greater than one, of the wavelength.

The specification at page 10, line 14, to page 11, line 14, describes a number of advantages of using thicker antireflective layers by selecting a thickness that is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer. For instance, the increased thickness achieves improved film consistency from wafer to wafer; provides better control of the refractive index, absorptive index, and thickness of the film; and renders the film suitable for use as a hard mask during an etching step. These are not disclosed or suggested in Lee.

The Examiner alleges that it would have been obvious to realize that odd multiples of the radians as disclosed in Lee would have the same phase angle. Assuming that were the case, there would be no reason to use odd multiples of greater than one since the same phase angle would be present. There is no suggestion to use such odd multiples of greater than one. It is the inventors, not the cited references, that disclosed the reasons for using the odd multiples of greater than one (e.g., to achieve improved film consistency from wafer to wafer; provide better control of the refractive index, absorptive index, and thickness of the film; and render the film suitable for use as a hard mask during an etching step).

The Examiner alleges that "Lee clearly teaches Applicant's claimed distance as being a multiple, less than one, of the wavelength of light," and that "as such, it is accepted that one of ordinary skill in the art at the time the invention was made would have found it obvious to optimize the operation of the claimed apparatus to achieve the claimed distance."

<u>The Examiner's allegation is **baseless**</u>. It is unfathomable how Lee's teaching would suggest a layer to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer. The Examiner alleges that it would have been obvious to optimize the operation of the claimed invention as discussed in Lee at column 3, line 62, to column 4, line 27. Lee states: "Optimization of the thickness of phase-shift layer 12 is discussed in FIG. 2." Column 3, lines 62-64. The optimization disclosed in Lee is "to optimize the phase shift desired from phase-shift mask 10 to obtain a 180 degrees shift between areas 12' and 13' that are phase shifted and areas 17 that are not phase shifted" (col. 5, lines 5-8). The 180 degree phase shift is the optimization taught in Lee. Lee is completely devoid of any suggestion of a layer to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer. The claimed invention is <u>not</u> mere optimization of a known process.

For at least the foregoing reasons, independent claim 1 and dependent claims 2-6, 9, and 10 are patentable.

<u>Claim Group 2</u>

Claims 44-50 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. '199 in view of Batey et al. and Lee.

Applicants respectfully submit that independent claim 44 is patentable over the cited references because, for instance, they do not teach or suggest a computer readable program code for controlling the gas delivery system to operate for a specified time period and for causing a layer to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer.

As discussed above in connection with claim group 1, it is the inventors, not the cited references, that disclosed the reasons for using the odd multiples of greater than one (e.g., to achieve improved film consistency from wafer to wafer; provide better control of the refractive index, absorptive index, and thickness of the film; and render the film suitable for use as a hard mask during an etching step).

For at least the foregoing reasons, independent claim 44 and dependent claims 45-50 are patentable.

Claim Group 3

Claim 51 depends from claim 44, and stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. '199 in view of Batey et al. and Lee, and further in view of Felts et al. '665. Claim 51 is patentable for at least the same reasons that claim 44 is patentable. Moreover, claim 51 recites that the substrate support is spaced from the gas distribution system at a distance in the range of 200-600 mils. Felts et al. '665 does not cure the deficiencies of the other references. Thus, claim 51 is patentable.

Claim Group 4

Claim 52 depends from claim 44, and stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. '199 in view of Batey et al. and Lee, and further in view of Collins et al. Claim 52 is patentable for at least the same reasons that claim 44 is patentable. Moreover, claim 52 recites that the selected deposition gases further comprise NH_3 flowed into the chamber at a rate of less than 300 sccm, and N_2 flowed into the chamber at a rate of less than 4000 sccm. Collins et al. '665 does not cure the deficiencies of the other references. Thus, claim 52 is patentable.

Claim Group 5

Independent claim 53 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. '199 in view of Batey et al. and Lee.

Claim 53 is submitted to be patentable because, for instance, the references do not disclose or suggest a set of computer instructions for controlling the gas delivery system to operate for a specified time period and for causing the antireflective layer to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer.

As discussed above in connection with claim group 1, it is the inventors, not the cited references, that disclosed the reasons for using the odd multiples of greater than one (e.g., to achieve improved film consistency from wafer to wafer; provide better control of the refractive index, absorptive index, and thickness of the film; and render the film suitable for use as a hard mask during an etching step). Thus, claim 53 is patentable.

Claim Group 6

Independent claim 54 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. '199 in view of Batey et al. and Lee.

Claim 54 is patentable because, for instance, the references do not teach or suggest a set of computer instructions for controlling the gas delivery system to operate for a specified time period and for causing the film to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the film.

As discussed above in connection with claim group 1, it is the inventors, not the cited references, that disclosed the reasons for using the odd multiples of greater than one (e.g., to achieve improved film consistency from wafer to wafer; provide better control of the refractive index, absorptive index, and thickness of the film; and render the film suitable for use as a hard mask during an etching step). Accordingly, claim 54 is patentable.

Claim Group 7

Independent claim 55 and claim 56 depending therefrom stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. '199 in view of Batey et al. and Lee.

Claims 55 and 56 are patentable because, for instance, the references fail to disclose or suggest means for causing the layer to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the thin film.

As discussed above in connection with claim group 1, it is the inventors, not the cited references, that disclosed the use of odd multiples of greater than one, for instance, to achieve improved film consistency from wafer to wafer; provide better control of the refractive index, absorptive index, and thickness of the film; and render the film suitable for use as a hard mask during an etching step. None of the references provide the motivation to use odd multiples of greater than one. For at least the foregoing reasons, claims 55 and 56 are patentable.

Claim Group 8

Independent claim 57 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. '199 in view of Batey et al. and Lee.

Claim 57 is patentable because, for instance, the references do not teach or suggest means for flowing N_2O through the gas distribution system at a flow rate of 5-300 sccm, wherein a ratio of the selected flow rate of He to the combined flow rate of SiH_4 and N_2O is at least 6.25:1 to deposit an antireflective layer on the substrate at a deposition rate which is lower than a deposition rate using the same flow rate of SiH_4 and the same flow rate of N_2O with a lower flow rate of He and to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the antireflective layer. This feature is completely absent from the cited references.

Claim Group 9

Claims 58 and 59 depend from claim 57, and stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. '199 in view of Batey et al. and Lee, and further in view of Collins et al. Claims 58 and 59 are patentable for at least the same reasons that claim 57 is patentable. Moreover, claim 58 from which claim 59 depends recites means for introducing NH_3 into the chamber at a rate of 0-300 sccm. Collins et al. '665 does not cure the deficiencies of the other references. Thus, claims 58 and 59 are patentable.

Claim Group 10

Independent claim 60 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Batey et al. in view of Lee.

Applicants respectfully submit that claim 60 is patentable over the cited references because, for instance, they do not teach or suggest means for forming a layer of photoresist on the antireflective layer, the antireflective layer having a thickness and refractive indices such that a first reflection from an interface between the photoresist and the antireflective layer of an exposure light will be an odd number which is at least 3 multiplied by 180° out of phase with a second reflection from an interface between the antireflective layer and the substrate layer of the exposure light.

The Examiner cites Lee for merely disclosing that a first reflection from an interface between the photoresist layer and the antireflective layer of an exposure light is an odd number, but it is not at least 3 multiplied by 180° (π in radians) out of phase with a second reflection from an interface between the antireflective layer and the substrate layer of the exposure light. Nothing in Lee teaches or suggests a thickness that is an odd multiple, greater

than one, of the wavelength. As discussed above in connection with claim group 1, the specification at page 10, line 14, to page 11, line 14, describes a number of advantages of using thicker antireflective layers by selecting a thickness that is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer. For instance, the increased thickness achieves improved film consistency from wafer to wafer; provides better control of the refractive index, absorptive index, and thickness of the film; and renders the film suitable for use as a hard mask during an etching step. These are not disclosed in Lee.

Even if combined, therefore, Felts '665, Batey et al., and Lee do not render claim 60 unpatentable. Accordingly, claim 60 is patentable.

Claim Group 11

Independent claim 61 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Batey et al. in view of Lee.

Applicants submit that claim 61 is patentable over the cited references because, for instance, they do not disclose or suggest means for forming a photoresist pattern by exposing the photoresist layer to an exposure light having a wavelength of 365 nm or less and developing the exposed photoresist layer, wherein a phase shift of an odd multiple of at least 3 multiplied by 180° exists between a first reflection of the exposure light from an interface between the photoresist layer and the antireflective layer and a second reflection of the exposure light from an interface between the antireflective layer and the first layer, the first reflection having almost the same intensity as the second reflection to thereby substantially cancel the first and second reflections. As discussed above in connection with claim group 10, nothing in Lee teaches or suggests a thickness that is an odd multiple, greater than one, of the wavelength. Accordingly, claim 61 is patentable.

The Examiner alleges that Applicants argue that the cited references do not teach light exposure at wavelengths of 365 nm or less. The Examiner's allegation is **false**. Instead, Applicants contend that claim 61 is patentable over the cited references because, for instance, they do not disclose or suggest means for forming a photoresist pattern by exposing the photoresist layer to an exposure light having a wavelength of 365 nm or less and developing the exposed photoresist layer, wherein a phase shift of an odd multiple of at least 3 multiplied by 180° exists between a first reflection of the exposure light from an interface

between the photoresist layer and the antireflective layer and a second reflection of the exposure light from an interface between the antireflective layer and the first layer, the first reflection having almost the same intensity as the second reflection to thereby substantially cancel the first and second reflections. That is, Lee and the other references do not disclose or suggest the recited features, not merely light exposure at wavelengths of 365 nm or less.

The Examiner further alleges that Applicants argue that the references fail to show certain features of the claimed invention, but those features relied upon are not cited in the rejected claims (i.e., "the first reflection having almost the same intensity as the second reflection to thereby substantially cancel the first and second reflection"). <u>Again, the Examiner's allegation is **false**</u>. The argued feature is recited in claim 61.

<u>Claim Group 12</u>

Independent claim 62 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. '199 in view of Batey et al. and Lee.

Applicants respectfully assert that claim 62 is patentable over the cited references because, for instance, they do not disclose or suggest means for depositing a thin film on the substrate at said low deposition rate from said reaction of said deposition gases to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the thin film. As discussed above in connection with claim group 10, nothing in Lee teaches or suggests a thickness that is an odd multiple, greater than one, of the wavelength. Accordingly, claim 62 is patentable.

X. <u>CONCLUSION:</u>

In view of the foregoing arguments distinguishing claims 1-6, 9, 10 and 44-62 over the art of record, Applicants respectfully submit that the claims are in condition for allowance, and respectfully request that the rejection of these claims be reversed.

Respectfully submitted,

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Encl.: Appendix of claims involved in appeal

APPENDIX

1. A substrate processing system, comprising:

a vacuum chamber;

a substrate supporter, located within the vacuum chamber, for holding a substrate;

a gas manifold for introducing process gases into the chamber;

a gas distribution system, coupled to the gas manifold, for distributing the process gases to the gas manifold from gas sources;

a power supply coupled to the gas manifold;

a vacuum system for controlling pressure within the vacuum chamber;

a controller, including a computer, for controlling the gas distribution system, the power supply and the vacuum system; and

a memory coupled to the controller comprising a computer readable medium having a computer readable program code embodied therein for directing operation of the substrate processing system, the computer readable program code including:

computer readable program code for causing the gas distribution system to introduce a first process gas comprising a mixture of SiH_4 and N_20 into the chamber to deposit a first plasma enhanced CVD layer over the wafer;

computer readable program code for causing the gas distribution system to introduce a second process gas comprising He into the chamber to control the deposition rate of the first layer; and

computer readable program code for controlling the gas distribution system to operate for a specified time period and for causing the first plasma enhanced CVD layer to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer.

2. A substrate processing system as in claim 1 wherein the computer readable program code for causing the gas distribution system to introduce the first process gas comprising a mixture of SiH_4 and N_20 into the chamber controls the introduction of the SiH_4 to be between 5 to 300 sccm, and the rate of N_20 to be between 5 to 300 sccm.

3. A substrate processing system as in claim 2 wherein the computer readable program code for causing the gas distribution system to introduce a second process gas comprising He into the chamber controls the chamber pressure at about 1 to 6 torr, the chamber pressure being the pressure inside the chamber.

4. A substrate processing system as in claim 3 wherein the computer readable program code for causing the gas distribution system to introduce the first process gas comprising a mixture of SiH_4 and N_20 into the chamber controls the introduction of the SiH_4 to be at a volumetric flow rate of between 0.5 to 3 times the volumetric flow rate of N_20.

5. A substrate processing system as in claim 1 further comprising:

computer readable program code for causing the gas distribution system to introduce a third process gas comprising NH_3 into the chamber; and

computer readable program code for causing the gas distribution system to introduce a fourth process gas comprising N_2 into the chamber.

6. A substrate processing system as in claim 5 wherein:

the computer readable program code for causing the gas distribution system to introduce a third process gas comprising NH_3 into the chamber controls the introduction of the NH_3 to be between a rate of 0 to 300 sccm; and

the computer readable program code for causing the gas distribution system to introduce a fourth process gas comprising N_2 into the chamber controls the introduction of the N_2 to be between a rate of 0 to 4000 sccm.

7-8. (canceled)

9. A substrate processing system as in claim 2 wherein the computer readable program code for causing the gas distribution system to introduce the first process gas comprising a mixture of SiH_4 and N_20 into the chamber controls the introduction of the SiH_4 to be between 15 to 160 sccm, and the rate of N_20 to be between a rate of 15 to 160 sccm.

10. A substrate processing system as in claim 9 further comprising:

computer readable program code for causing the gas distribution system to introduce a third process gas comprising NH_3 into the chamber at a rate of less than 150 sccm; and

computer readable program code for causing the gas distribution system to introduce a fourth process gas comprising N_2 into the chamber at a rate of less than 300 sccm.

11-43. (canceled)

44. A substrate processing system, comprising:

a process chamber;

a substrate support, located within the process chamber, for supporting a substrate;

a power supply;

a gas delivery system for delivering process gases into the process chamber;

a controller configured to control the power supply and the gas delivery system; and

a memory coupled to the controller comprising a computer readable medium having a computer readable program embodied therein for directing operation of the substrate processing system, the computer readable program including a first set of computer instructions for controlling the gas delivery system to introduce selected deposition gases into the process chamber at deposited gas flow rates, a second set of computer instructions for controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a plasma enhanced reaction of the selected deposition gases, the desired low deposition rate being lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas, a third set of computer instructions for controlling the power supply to supply power to the process chamber to produce a plasma enhanced reaction of the deposition gases in the process chamber to deposit a film at the low deposition rate, and a fourth set of computer instructions for controlling the gas delivery system to operate for a specified time period and for causing the film to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the film.

45. The substrate processing system of claim 44 wherein the inert gas comprises helium.

46. The substrate processing system of claim 44 wherein the selected deposition gases comprise silane and an oxygen source.

47. The substrate processing system of claim 44 wherein the selected deposition gases comprise silane and nitrous oxide.

48. The substrate processing system of claim 44 wherein the selected deposition gases comprise silane and a nitrogen source.

49. The substrate processing system of claim 44 further comprising a vacuum system for controlling pressure within the process chamber, and wherein the computer-readable program further comprises a fifth set of computer instructions for controlling the vacuum system to maintain a chamber pressure in the range of 1-6 Torr, and wherein the selected deposition gases comprise SiH_4 flowed into the chamber at a rate of 5-300 sccm and N_2O flowed into the chamber at a rate of 5-300 sccm.

50. The substrate processing system of claim 49 further comprising a heater for heating the substrate, and wherein the computer-readable program further comprises a fifth set of computer instructions for controlling the heater to heat the substrate to a temperature in the range of 200-400°C.

51. The substrate processing system of claim 50 wherein the substrate support is spaced from the gas distribution system at a distance in the range of 200-600 mils.

52. The substrate processing system of claim 49 wherein the selected deposition gases further comprise NH_3 flowed into the chamber at a rate of less than 300 sccm, and N_2 flowed into the chamber at a rate of less than 4000 sccm.

53. A substrate processing system, comprising:

a process chamber;

a substrate support, located within the process chamber, for supporting a substrate;

an RF power supply;

a heater;

a gas delivery system for delivering process gases into the process chamber;

a controller configured to control the power supply and the gas delivery system; and

a memory coupled to the controller comprising a computer readable medium having a computer readable program embodied therein for directing operation of the substrate processing system, the computer readable program including a first set of computer instructions for controlling the gas delivery system to flow He into the process chamber at a selected flow rate to provide a chamber pressure in the range of 1-6 Torr, a second set of computer instructions for controlling the RF power supply to supply power of 50-500 Watts to the process chamber, a third set of computer instructions for controlling the heater to heat the substrate to a temperature in the range of 200-400°C, a fourth set of computer instructions for controlling the gas delivery system to flow SiH_4 at a flow rate of 5-300 sccm into the process chamber, a fifth set of computer instructions to flow N_2O at a flow rate of 5-300 sccm into the process chamber, wherein a ratio of the selected flow rate of He to the combined flow rate of SiH_4 and N_2O is at least 6.25:1 to deposit an antireflective layer on the substrate at a deposition rate which is lower than a deposition rate using the same flow rate of SiH_4 and the same flow rate of N_2O with a lower flow rate of He, and a sixth set of computer instructions for controlling the gas delivery system to operate for a specified time period and for causing the antireflective layer to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer.

54. A substrate processing system, comprising:

a process chamber;

a substrate support, located within the process chamber, for supporting a substrate;

a power supply;

a gas delivery system for delivering process gases into the process chamber;

a controller configured to control the power supply and the gas delivery system; and

a memory coupled to the controller comprising a computer readable medium having a computer readable program embodied therein for directing operation of the substrate processing system, the computer readable program including a first set of computer instructions for controlling the gas delivery system to flow selected deposition gases into the process chamber at deposition gas flow rates, a second set of computer instructions for

controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a reaction of the selected deposition gases, the desired low deposition rate being lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas, a third set of computer instructions for controlling the power supply to supply power to the process chamber to react the deposition gases to deposit a film at the low deposition rate, and a fourth set of computer instructions for controlling the gas delivery system to operate for a specified time period and for causing the film to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the film.

55. A substrate processing system comprising:

a process chamber;

a substrate support, located within the process chamber, for supporting a substrate;

a gas delivery system for delivering selected deposition gases into the process chamber at deposition gas flow rates;

means for adding a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from plasma enhanced reaction of the selected deposition gases, the desired low deposition rate being lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas; and

means for depositing a thin film at the low deposition rate from a plasma enhanced reaction of the deposition gases and for causing the thin film to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the thin film.

56. The system of claim 55 further comprising:

means for maintaining a chamber pressure of the process chamber in the range of 1-6 Torr; and

means for heating the substrate to a temperature in the range of 200-400°C.

57. A substrate processing system comprising:

a processing chamber;

a substrate support, located within the processing chamber, for supporting a substrate;

means for flowing He into the processing chamber at a selected flow rate to provide a chamber pressure in the range of 1-6 Torr;

means for connecting the chamber to an RF power supply to receive 50-500 Watts;

means for heating the substrate to a temperature in the range of 200-400°C;

means for flowing SiH_4 through a gas distribution system at a flow rate of 5-300 sccm; and

means for flowing N_2O through the gas distribution system at a flow rate of 5-300 sccm, wherein a ratio of the selected flow rate of He to the combined flow rate of SiH_4 and N_2O is at least 6.25:1 to deposit an antireflective layer on the substrate at a deposition rate which is lower than a deposition rate using the same flow rate of SiH_4 and the same flow rate of N_2O with a lower flow rate of He and to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the antireflective layer.

58. The system of claim 57 further comprising means for introducing NH_3 into the chamber at a rate of 0-300 sccm.

59. The system of claim 58 further comprising means for introducing N_2 into the chamber at a rate of 0-4000 sccm.

60. A substrate processing system comprising:

a substrate processing chamber;

a substrate support, located within the process chamber, for supporting a substrate;

a gas delivery system for delivering process gases into the substrate processing chamber;

means for forming an antireflective layer over a layer on the substrate by flowing selected deposition gases into the substrate processing chamber at deposition gas flow rates and adding a flow of an inert gas to the selected deposition gases to deposit the

antireflective layer at a desired deposition rate which is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas;

means for forming a layer of photoresist on the antireflective layer, the antireflective layer having a thickness and refractive indices such that a first reflection from an interface between the photoresist and the antireflective layer of an exposure light will be an odd number which is at least 3 multiplied by 180° out of phase with a second reflection from an interface between the antireflective layer and the substrate layer of the exposure light; and

means for forming a photoresist pattern by exposing the photoresist layer to the exposure light and developing the exposed photoresist layer.

61. A substrate processing system comprising:

a substrate processing chamber;

a substrate support, located within the process chamber, for supporting a substrate;

a gas delivery system for delivering process gases into the substrate processing chamber;

means for forming an SiON antireflective layer over a first layer on the substrate by flowing selected deposition gases into the substrate processing chamber at deposition gas flow rates and adding a flow of an inert gas to the selected deposition gases to deposit the SiON antireflective layer at a desired deposition rate which is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas, said antireflective layer having a refractive index in the range of 1.7-2.9, an absorptive index in the range of 0-1.3, and a thickness in the range of 200-3000 angstroms;

means for forming a layer of photoresist over the antireflective layer; and

means for forming a photoresist pattern by exposing the photoresist layer to an exposure light having a wavelength of 365 nm or less and developing the exposed photoresist layer, wherein a phase shift of an odd multiple of at least 3 multiplied by 180° exists between a first reflection of the exposure light from an interface between the photoresist layer and the antireflective layer and a second reflection of the exposure light from an interface between the

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antireflective layer and the first layer, the first reflection having almost the same intensity as the second reflection to thereby substantially cancel the first and second reflections.

62. A substrate processing system comprising:

a substrate processing chamber;

a substrate support, located within the process chamber, for supporting a substrate;

a gas delivery system for delivering process gases into the substrate processing chamber;

means for flowing selected deposition gases into the substrate processing chamber at deposition gas flow rates;

means for adding a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a reaction of the selected deposition gases, said desired low deposition rate being lower than a deposition rate using said selected deposition gases at said deposition gas flow rates with a lower flow rate of said inert gas; and

means for depositing a thin film on the substrate at said low deposition rate from said reaction of said deposition gases to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the thin film.